PATENT SPECIFICATION

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(54) IMPROVEMENTS IN UNDER-PINNING

(71) We, PYNFORD LIMITED, a British company, of 74 Lancaster Road, London, N.4., do hereby declare the invention, for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:—

Conventional techniques used for underpinning the walls of buildings involve digging a pocket beneath the existing foundations and packing the pocket with concrete to form a new support. Further pockets are cut and packed, either contiguous with one another to form a continuous new footing, or at intervals spaced along the wall if the load in the wall is picked up and transmitted to the new supports through a beam, such as a "Pynford" (Registered Trade Mark) beam which extends along, and in, the plane of the wall. However these techniques suffer from the disadvantage that they depend upon the new supports extending down into the ground far enough to take an adequate reaction from stable earth. It frequently happens that the subsidence making the underpinning necessary is produced by the drying out of a bed of clay beneath the wall, as a result of a change in surrounding water table, or by the root system of a mature tree extending beneath the wall and drawing the moisture from the clay. Analogous problems can arise when a mature tree is felled leaving the clay previously dried out by the root system of the tree free to swell again upon its moisture content increasing into equilibrium with the surrounding ground. Since the root system of a mature tree may extend 3 m. or even up to 5 m. in exceptional cases below ground level, it is then necessary for the pockets for the new underpinning supports to be dug a greater distance into the ground. At this depth it is physically impossible for the pocket to be dug and the earth to be thrown out by hand and it is necessary to use hoists or mechanical diggers. Not only do these add considerably to the cost of the job but they are often difficult to manipulate in the limited space available below the wall, at least without making the pockets much larger than they need otherwise be with the consequent extra expense in time and materials.

In accordance with the present invention, a method of underpinning a load bearing wall comprises inserting a cluster of needle piles downwards into the ground adjacent to the bottom of the wall and casting a concrete pile cap which unites the upper ends of the piles and which transmits the load from the wall to the piles.

The piles may be inserted into the ground to one or both sides of the wall, although this may involve temporarily lifting the floor at the inside of the wall. Alternatively, the piles may be put down beneath the wall. In that case a pocket is cut beneath the wall and piles are inserted downwards into the ground through the bottom of the pocket which is subsequently packed with concrete to form the pile cap, each of the piles being built in sections by successively inserting a section of the pile in the pocket down through the bottom of the pocket and attaching the lower end of the next section to the upper end of the section just inserted.

The new method has a number of very important advantages. Thus it is only necessary to dig a comparatively small pocket to accommodate the pile cap and even if the piles are driven beneath the wall, the pocket need only be say 1 m. deep in which to work. The pocket can be dug quickly and easily and the amount of concrete necessary to fill it is small. It is estimated that the new operation may reduce the cost of underpinning of up to 25% or more.

The needle piles, by which we mean piles of any cross-sectional shape but having a width of up to 100 mm., and preferably between 25 and 65 mm., can be quickly inserted into the ground down to a depth of 6

or 7 m., using comparatively simple equipment. The piles are inserted in until the foot of the pile forces its way say 3 or 4 m. into stable soil, as indicated by a given reaction force being reached. Relying primarily on skin friction between the lower 4 metres of its length and the surrounding stable earth, we estimate that a circular pile having a diameter of 50 mm. can support a load of 4½ tons that is a safe load of 1½ tons and piles of different diameter, a load pro rata with their diameter. An equivalent force of 4½ tons to insert such a pile is then readily available from conventional portable jacking units with or without additional vibration equipment to reduce the friction between the pile and the surrounding ground during pile insertion. Owing to their slenderness, such piles cannot accommodate much bending stress and an appropriate jacking unit would incorporate a chuck for successively gripping the pile and pushing it down say 50 cm. or more at each stroke. Although each pile is only capable of accommodating a safe load of 2 tons or a little more, depending upon its width, that is all that is necessary. The total load bearing capacity of the cluster of piles is higher the greater the number of piles and as many piles as necessary can therefore be driven in one after the other. Because each pile in the cluster is designed to take only a proportion of the load to be carried by the whole cluster, it is possible to insert each pile individually using a jacking unit which takes its reaction from the wall being underpinned, that is the load to be carried, without the need of additional heavy equipment. In practice we anticipate using at least three and preferably six or more piles in a cluster. Six is a convenient lower limit because this number will allow for the dead weight being underpinned being only half the combined live and dead weight of the building in use, and for the safety factor of three to which such structures usually designed.

As is conventional, the load of the wall being underpinned may be redistributed onto the new foundations by a reinforced concrete beam extending along the bottom of the wall in the plane of the wall. In that case the pile cap may be united with the beam. The beam also provides a suitable member from which the jacking unit can take its reaction for the pile insertion.

The construction of each pile may take a variety of forms. For example, each pile may be made of resin impregnated concrete, or a concrete reinforced with carbon, polymer, asbestos, glass or metal fibres, or with a reinforcement rod of prestressed or unstressed wires extending along its length. The concrete pile may then be encased in a metal sleeve, such as of galvanized iron to assist in the pile being inserted smoothly into the ground. If the metal sleeve subsequently rusts away this will not matter as it is not responsible for the strength of the pile and in any case the rusting of the metal will involve an increase in volume which will act to hold the pile even more firmly in the ground. Alternatively, each pile may be made of metal or other material in the form of a solid rod or tube. If the compressive strength of the pile is dependent on metal, the metal selected must be non-corrosive and a rust-resistant steel is appropriate. The degree of rust resistance will depend on analysis of the soil present in the ground. For certain applications the pile may be constructed from a lower section or sections of reinforced concrete and an upper section or sections of perforated metal.

When the needle piles have been inserted into position, the working pocket will be filled with concrete to produce the pile cap. Prior to the placing of the concrete, a jacking unit used for driving in the piles may be recovered from the pocket for subsequent use. If the load is not being redistributed through a preformed beam to the new foundations, it may also be useful at this stage to jack up the wall of the building relatively to the top of the cluster of needle piles, to take up any looseness in the wall, and to retain the wall in this condition relatively to the needle piles by a dead shoring technique during placing of the concrete for the pile cap.

The swelling of a bed of clay beneath a wall, for example, as a result of a mature tree being felled, may produce an upward pushing action on the building above the bed. This pushing action may cause distortion of the building analogous to that produced by subsidance, but its effect may not be entirely overcome simply by the ground anchor effect of the pile cluster extending down through the bed into the stable earth beneath. However, the problem can be overcome by providing beneath the pile cap a layer of resilient or crushable material, such as foam polystyrene, which will give and absorb any upward movement of the earth below. The load is thus effectively carried through the pile cap and the pile cluster down to the stable earth and is protected by the resilient or crushable material from any upward movement beneath the concrete. The rezilient or crushable material will be placed in the bottom of the working pocket prior to placement of the concrete.

The existence of disturbed ground requiring the underpinning, may cause horizontal as well as vertical movements. The vertical movements are accommodated by taking the needle piles down to stable earth but the slenderness of the piles gives

them little resistance to horizontal movements, against which the building must also be protected. One solution is to provide sliding surfaces between the bottom of the existing wall foundation and the top of the pile cap. The pile cap would then be free to move horizontally but would still maintain a stable vertical support. Alternatively, the pile cap could be given resistance against lateral movement by causing some of the needle piles to be inserted at an appreciable angle to the vertical so that they provide an appreciable component of lateral support. We prefer, however, to give the pile caps resistance against horizontal movement by fixing them together. This may be achieved by uniting the pile caps with a beam which redistributes the load of the wall to the new foundations. If no beam is present, the same result may be achieved by driving tie rods through the working pockets, for example, from a pit at one end of the wall, prior to placing the concrete for the pile caps in the pockets. Alternatively, the soil between the pockets may be dug out, leaving the wall shored up from the cluster of pile supports in the pockets, and forming an integral concrete pile cap through all the pockets. The use of the needle piles for shoring up the building during the casting of this concrete can be likened to the stooling technique used in producing "Pynford" (Registered Trade Mark) beam, the individual needle piles corresponding to the legs of the stool.

If the pile caps are maintained stable in both horizontal and vertical directions, then horizontal movement of the ground will transmit lateral pressures to the sides of the needle piles with a consequent danger of the slender piles snapping adjacent to the pile caps. This danger may be overcome by surrounding each needle pile below the pile cap and within the bed of unstable ground with a material which will absorb lateral thrust and prevent it from being transmitted directly to the pile. Such material may be Bentonite slurry, sand, pea single, or other fluent material; or a crushable or resilient collar of, for example, cardboard or cellular plastics material. In order to prevent such a collar from being stripped from the pile during pile insertion, it may be necessary to prebore the ground to a depth sufficient to accommodate the material which absorbs lateral pressures. The pre-bored hole will not, of course, extend down into the stable earth into which the foot of the pile will be driven to take the load bearing reaction. Alternatively the top of the pile may simply be protected by a void, in which case the pre-bored hole will remain unfilled.

The material surrounding the pile immediately below the pile cap may be porous and arranged to enable water to percolate into the surrounding ground through the pile cap or otherwise from above. For this purpose at least the upper portion of the pile may be constructed of perforated tubular metallic sections, for example stainless steel, and/or the collar of material surrounding the pile beneath the pile cap may be porous and may incorporate in appropriate conditions, an anti-freeze agent. When used in, for example, a bed of dried out clay, the moisture percolating into the clay beneath the pile cap will then soften up the clay and provide a lubrication effect enabling the clay to "slip around" the piles in the event of horizontal movement. Such "wetting up" may be desirable when a mature tree has been felled and the clay has been previously dried out by its root system.

Two examples of the underpinning of a load bearing wall in accordance with the invention are illustrated in the accompanying drawings, in which:—

Figure 1 is a vertical cross section through a wall with underpinning work in progress;

Figure 2 is a view corresponding to Figure 1 but showing the work complete;

Figure 3 is a part axial section showing the inter-connection between adjacent pile sections;

Figure 4 is a section corresponding to Figure 1 but showing underpinning work in progress on a second wall;

Figure 5 is a section corresponding to Figure 4 and taken on the line V—V in Figure 6, showing the work complete; and,

Figure 6 is a horizontal section showing a corner part of the wall with its underpinnings supports.

In both the examples a cavity wall 7, having a damp proof course 8, is shown after being provided with a reinforced concrete "Pynford" (Registered Trade Mark) beam 9 for redistributing the load of the wall onto new foundations. Dry packing 10 is interposed between the wall and the beam 9. Figures 4 and 5 indicate the original foundation 11, in the form of a concrete footing, which is no longer sufficient to support the wall owing to the immediately surrounding ground 12 being unstable.

In the first example a working pocket 13 is dug from the outside of the wall beneath the wall and starter holes 14 are bored to a depth of about 2 metres. A pile 16 is then inserted down through each hole in turn using a jacking unit having a frame 17 which is lodged between the beam 9 and the base of the pocket 13. Each pile is formed in sections 16A which are driven one after the other, the leading end of a section to be inserted being coupled to the trailing end of the section previously driven by a metal sleeve 18 which fits over reduced diameter portions 19 of the pile sections. The jacking unit has a pair of double acting hydraulic

cylinders 20 the rods of which are pivoted to a cross head 21 connected via arms to a one-way chuck 22. As the rams 20 are extended the chuck 22 can ride up the pile 16 and when the rams are retracted downwards the chuck automatically grips the pile and draws it downwards with a working stroke of about 30 cms.

Each pile is extended and advanced into the ground until the desired upward reaction is obtained. It can be expected that this will occur when the foot of the pile has entered load bearing ground 23 to a depth of say 4 metres. The jacking unit is then resited in the pocket and the next pile driven in and so on.

After the piles have been inserted, the jacking unit is removed from the working pocket, and if necessary form work is introduced into the pocket. The annular space between the top of each pile and the wall of the prebored hole 14 will be filled with fluent, resilient or crushable material 24 and a layer 24A of the material may be placed in the bottom of the pocket. A concrete pile cap 25 is then cast in the form work, uniting the cluster of piles to one another and is pinned up to the underside of the beam 9. The procedure is then repeated as and where necessary at intervals along the wall 7.

The second example differs from the first in that the pocket 13A is dug both on the outside of the wall and on the inside of the wall after lifting the existing floor 26 and does not have to be dug to a working depth beneath the wall. In this case piles are put down both on the inside and the outside of the wall by a jacking unit which takes its reaction from the beam 9, not via a frame below the beam, but via a rigid base plate 27 which is temporarily bolted to the beam 9. In this case the pile cap 25A is united on both sides of the beam 9 with the beam. Steel reinforcement 28 which has previously been cast in the beam 9 and left projecting from the beam, is embedded within the two parts of the pile cap to improve the connection.

In the second example continuous piles of standard length or in sections if required internally are used and when they have been inserted until the desired reaction is obtained the excess pile length at the top of the pile is cut off.

Figure 6 shows in plan the clusters of piles 16 and the pile caps 25A on each side of the wall and also an analogous configuration at the intersection of two walls.

WHAT WE CLAIM IS:—

1. A method of underpinning a loading bearing wall comprising inserting a cluster of needle piles (as herein defined) downwards into the ground adjacent to the bottom of the wall and casting a concrete pile cap which unites the upper ends of the piles and which transmits the load from the wall to the piles.

2. A method according to claim 1, in which a pocket is cut beneath the wall and the piles are inserted downwards into the ground through the bottom of the pocket which is subsequently packed with concrete to form the pile cap, each of the piles being built in sections by successively inserting a section of the pile in the pocket down through the bottom of the pocket and attaching the lower end of the next section to the upper end of the section just inserted.

3. A method according to claim 1, in which the piles are inserted into the ground or one or both sides of the wall.

4. A method according to any one of the preceding claims, in which a reinforced concrete beam is formed extending along the bottom of the wall in the plane of the wall and the pile cap is united with the beam.

5. A method according to claim 4, in which the piles are inserted into the ground by a jacking unit which takes its reaction from the beam.

6. A method according to any one of the preceding claims, in which the width of each pile is between 25 and 65 mm.

7. A method according to any one of the preceding claims, in which each pile is made of reinforced concrete.

8. A method according to claim 7, in which the reinforcement is carbon, polymer, asbestos, glass, or metal fibres.

9. A method according to any one of the preceding claims, in which each pile is inserted into the ground until a predetermined reaction is obtained.

10. A method according to claim 9, when dependent at least on claim 3, in which the piles are of standard length and an excess length is cut off after each pile has been inserted in the ground.

11. A method according to any one of the preceding claims, in which a starter hole for each pile is prebored and the clearance between the top of the pile and the prebored hole is, after the pile has been inserted, filled with a fluent, crushable, or resilient material, or left as a void.

12. A method according to any one of the preceding claims, in which a layer of crushable or reslient material is provided on the under side of the pile cap.

13. A method according to claim 1, substantially as described with reference to Figures 1 to 3 or to Figures 4 to 6, of the accompanying drawings.

13. A load bearing wall which has been underpinned by a method according to any one of the preceding claims.

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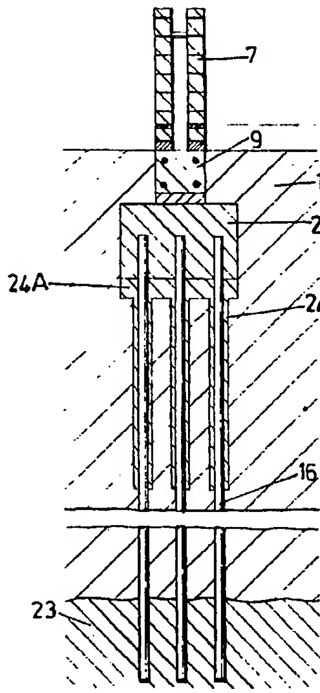

FIG. 2.

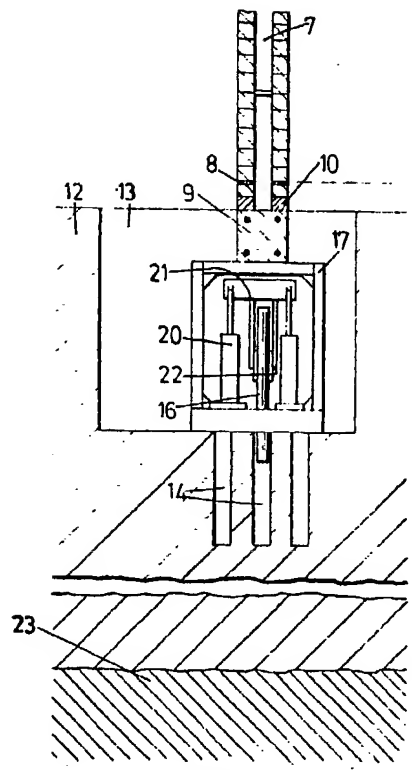

FIG. 1.

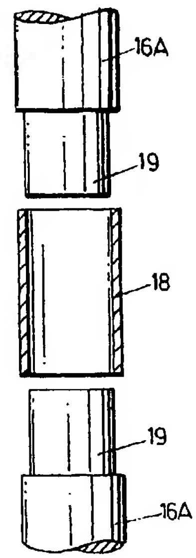

FIG. 3.

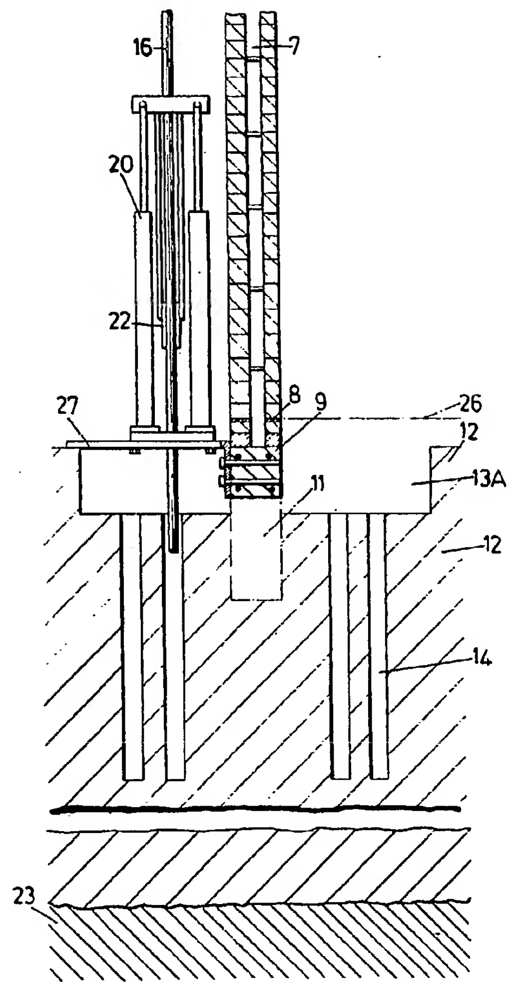

FIG. 4.

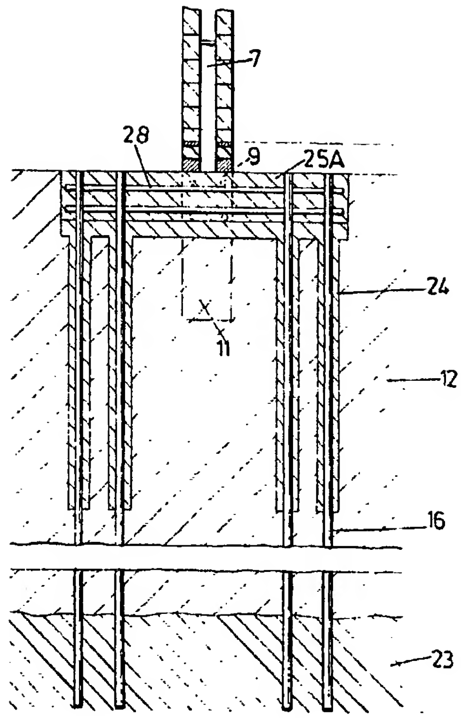

FIG.5.

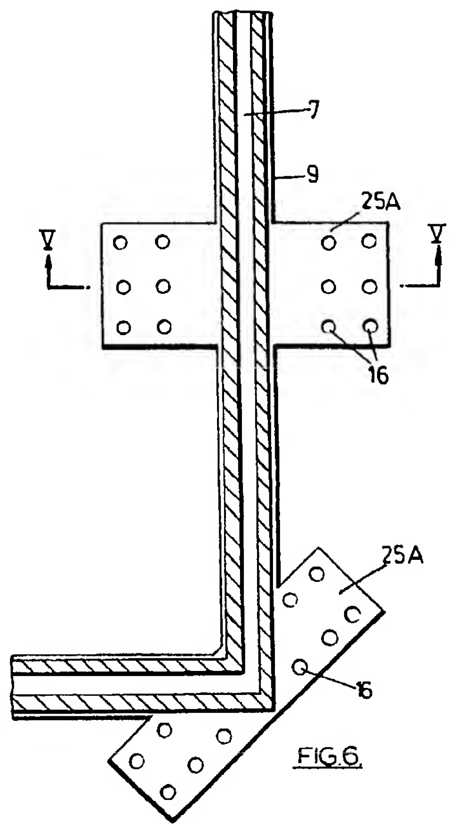

FIG.6.